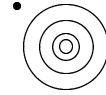


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DISTANT EKOs
The Kuiper Belt Electronic Newsletter



Edited by: Joel Wm. Parker

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`www.boulder.swri.edu/ekonews`

CONTENTS

News & Announcements	2
Abstracts of 8 Accepted Papers	4
Title of 1 Other Paper of Interest	8
Title of 3 Conference Contributions	9
Conference Information	9
Abstract of 1 Thesis	10
Newsletter Information	11

NEWS & ANNOUNCEMENTS

Two more binary TNOs have been discovered:

The discovery that (26308) 1998 SM165 is a binary TNO was announced in IAUC 7807 by Brown and Trujillo. The components differ in brightness by 1.9 mag, with a separation of 0.23 arcsec.

IAUC: <http://cfa-www.harvard.edu/iauc/07800/07807.html>

More information at: <http://www.gps.caltech.edu/~chad/1998SM165.html>

The discovery that 1997 CQ29 is a possible binary TNO was announced in IAUC 7824 by Noll et al.. The object is elongated in six WFPC2 images, extended by 0.17 arcsec.

IAUC: <http://cfa-www.harvard.edu/iauc/07800/07824.html>

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Can't keep track of 'em all? A new table of binary TNOs and their properties has been added to the *Distant EKOs* website:

<http://www.boulder.swri.edu/ekonews/objects/>

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F. Marchis and J. Berthier report that their TNO/Centaur appulse calculation web page was recently updated. It still can be found on the following web link

http://astron.berkeley.edu/~fmarchis/Science/TNOs_Appulse/

They have added several new features which will be useful for observers who wants to perform adaptive optics (AO) observations of TNOs and Centaurs:

- The list of targets used in the calculations has been updated up through 2001 VN71, and now also includes Pluton-Charon and all the minor bodies orbiting with a semi-major axis greater than 6 AU. (They note a possible occultation by Pluton-Charon of a 11.5 magnitude star on 2002 July 1.)
- The temporal step of the calculation was decreased to minimize the number of events missed. The complete calculation for one semester takes now around 1.5 week. The algorithm will be optimized at the end of the year to include a more sensitive catalog (i.e. UCAC) for the new Adaptive Optics systems (NAOS/VLT, Gemini, Subaru).
- A new column has been added to the tables called AEU (Appulse Ephemeris Uncertainties) which gives an estimate of the position accuracy of the TNO at the date of the appulse event. This parameter, derived from the CEU of the ASTORB table, is important to get an idea of the feasibility of an observation. Roughly half of the events may not be observable because of the low precision of the orbital elements of the TNO/Centaur orbit.
- Complete new calculations have been done for 2002 and 2003, resulting in typically ~200 "observable events" (AEU < 5 arcsec) per month.

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The results of a questionnaire to Planetary Scientists about the past accomplishments and future priorities in their field is available at:

<http://www.aas.org/~dps/decadal/>

The Kuiper belt figured prominently in both areas. It was voted one of the three most important discoveries in the past decade in planetary science, and a mission to Pluto and the Kuiper belt was voted as one of the three most important investigations that should be done in the next ten years (in fact, it got the most votes for any single priority). Meanwhile, according to the president's recent budget proposal, some politicians and accountants think otherwise...

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For those interested in other types of numerology, we have surpassed some milestones with now over 500 TNOs and over 100 Centaurs+SDOs on the MPC lists. That's the good news. The bad news is that of more than half of them (323) are single-opposition objects, 172 of which have no measurements for more than one year, and 105 of those have arcs less than 10 days. In other words, depending on your accounting practices and definitions: 11% of all objects (TNOs+Centaurs+SDOs) are endangered, and 17% more are effectively *lost*. On the *Distant EKO*s website I have added a plot of the rather sobering discovery and recovery statistics for folks to meditate on. See: <http://www.boulder.swri.edu/ekonews/objects/>
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There were 26 new TNO discoveries announced since the previous issue of the *Distant EKO*s Newsletter:

2001 DS108, 2001 DT108, 2001 XB255, 2001 XC255, 2001 XD255, 2001 XE255,
2001 XF255, 2001 XG255, 2001 XJ255, 2002 CO154, 2002 CP154, 2002 CQ154,
2002 CR154, 2002 CS154, 2002 CT154, 2002 CU154, 2002 CV154, 2002 CW154,
2002 CX154, 2002 CY154, 2002 CZ154, 2002 CA225, 2002 CB225, 2002 CW224,
2002 CX224, 2002 CZ224

and 9 new Centaur/SDO discoveries:

2001 KN77, 2001 KO77, 2001 KP77, 2001 KQ77, 2001 XH255, 2001 XZ255,
2002 CR46, 2002 CY224, 2002 DH5

Reclassified objects:

2000 CM114 (TNO → SDO)
2000 YU1 (TNO → SDO)
2001 QR322 (TNO → SDO)
2001 QX322 (TNO → SDO)
2001 UR163 (TNO → SDO)
2000 FF8 (SDO → TNO)
2000 SY370 (SDO → TNO)
2000 WM183 (SDO → TNO)
2001 KQ77 (SDO → TNO)
2001 UR163 (SDO → TNO)

Objects recently assigned numbers:

1995 QY9 = 32929
1997 CU29 = 33001
1998 BU48 = 33128
1998 VG44 = 33340
1998 SN165 = 35671

Re-identified objects:

2001 OQ108 = 2001 KR76

Current number of TNOs: 514 (and Pluto & Charon, and six other TNO binary companions)

Current number of Centaurs/SDOs: 101

**The Deep Ecliptic Survey:
A Search for Kuiper Belt Objects and Centaurs.
I. Description of Methods and Initial Results**

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We report here initial results of the Deep Ecliptic Survey, an ongoing new search for Kuiper belt objects (KBOs) and Centaurs using the 8Kx8K Mosaic CCD array on the 4 m Mayall Telescope at Kitt Peak National Observatory. Within the interval covered in this paper, useful observations were obtained during seven nights in 1998 October and November, 1999 April, and 2000 February. We used a novel technique to efficiently find and determine positions of moving objects. Sixty-nine KBOs and Centaurs with apparent magnitudes between 20.6 and approximately 24th magnitude were discovered. Nine or 10 of the newly discovered KBOs appear to be in the 3:2 mean motion resonance with Neptune and four appear to be scattered-disk objects. Three objects were found that may be in the 4:3 resonance. Sixty-two of the objects reported here have been observed on at least one additional night and have received designations. Our own follow-up astrometry was done primarily with the WIYN 3.5 m telescope in a queue-scheduled mode and with the Steward Observatory 90 inch (2.3 m) telescope. Others using a variety of telescopes recovered a significant number of our objects. Although not a primary objective of the survey, positions of all main-belt asteroids, Trojan asteroids, and nearby fast-moving asteroids seen in our data also have been determined, and most have been reported to the Minor Planet Center. Through simulations and analysis of the existing KBO database, we have investigated the uncertainty to be expected in various KBO orbital parameters as a function of the extent of the astrometric coverage. The results indicate that the heliocentric distance of an object and the inclination of its orbit can be narrowly constrained with observations from a single apparition. Accurate determination of semimajor axis and eccentricity, on the other hand, requires astrometric data extending over additional apparitions. Based on the observed distribution of orbital inclinations in our sample, we have estimated the true distribution of orbital inclinations in the Kuiper belt and find it to be similar to that of the short-period comets. This result is consistent with the commonly held belief that the Kuiper belt is the source region of the short-period comets.

To appear in: The Astronomical Journal

For preprints, contact `rlm@lowell.edu`

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Color Diversity among Kuiper Belt Objects: The Collisional Resurfacing Model Revisited

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A re-evaluation of the collisional resurfacing model based on up-to-date Kuiper belt objects size distribution and a more precise treatment of the cosmic-ray environment at the outer Solar System is presented. The result of the irradiation due to cosmic rays with different energies altered in a different way the material of the objects, producing, under certain conditions, a thick irradiation mantle. Since the collisional resurfacing model is based in the competition between darkening by cosmic rays and resurfacing due to impacts, the color of objects in different regions of the belt could vary if the projectile populations in those regions are truncated at a different radius.

Published in: Planetary and Space Science, 50, 57 (2002 January)

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Collision-induced Thermal Evolution of a Comet Nucleus in the Edgeworth-Kuiper Belt

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In this work, we attempt an order-of-magnitude estimate of the effects of heating caused by low-velocity collisions on the structure and composition of an Edgeworth-Kuiper belt object. This was done by using a numerical code developed for the study of comet nuclei. This code solves the heat conduction and gas diffusion equations in one dimension, within a spherically symmetric porous body made of a mixture of ices and dust. Ices can sublime, gas can flow within the porous matrix, and dust can be ejected by the gas flow escaping from the object. The code was adapted to the EKO case by adding the heat released by an impact in the interior of the body. Within the uncertainties in the values of parameters describing the EKO structure and the heat release due to impacts, it was found that the outcome of even a large collision cannot be taken for granted: in some cases, the impacted body is altered to depths of more than 1 km, while in some other cases very small effects are produced. The results also point to the interesting possibility of heat buildup within an EKO due to multiple impacts.

Published in: Advances in Space Research, 28, 1563 (2001)

For preprints, contact orosei@ias.rm.cnr.it

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Origins of Solar System Dust Beyond Jupiter

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The measurements of cosmic interplanetary dust by the instruments on board the Pioneer 10 and 11 spacecraft contain the dynamical signature of dust generated by Edgeworth-Kuiper belt objects, as well as short period Oort Cloud comets and short period Jupiter family comets. While the dust concentration detected between Jupiter and Saturn is mainly due to the cometary components, the dust outside Saturn's orbit is dominated by grains originating from the Edgeworth-Kuiper belt. In order to sustain a dust concentration that accounts for the Pioneer measurements, short period external Jupiter family comets, on orbits similar to comet 29P/Schwassmann-Wachmann-1, have to produce $8 \times 10^4 \text{ g s}^{-1}$ of dust grains with sizes between 0.01 and 6 mm. A sustained production rate of $3 \times 10^5 \text{ g s}^{-1}$ has to be provided by short period Oort cloud comets on 1P/Halley-like orbits. The comets can not, however, account for the dust flux measured outside Saturn's orbit. The measurements there can only be explained by a generation of dust grains in the Edgeworth-Kuiper belt by mutual collisions of the source objects and by impacts of interstellar dust grains onto the objects' surfaces. These processes have to release in total $5 \times 10^7 \text{ g s}^{-1}$ of dust from the Edgeworth Kuiper belt objects in order to account for the amount of dust found by Pioneer beyond Saturn, making the Edgeworth-Kuiper disk the brightest extended feature of the Solar System when observed from afar.

To appear in: *Astronomical Journal* (2002 May)

For preprints, contact Markus.Landgraf@esa.int

or on the web at <http://arXiv.org/abs/astro-ph/0201291>

A Dust Cloud Around Pluto and Charon

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We suggest that Pluto and Charon are immersed in a tenuous dust cloud. The cloud consists of ejecta from Pluto and — especially — Charon, released from their surfaces by impacts of micrometeoroids originating from Edgeworth-Kuiper belt objects. The motion of the ejected grains is dominated by the gravity of Pluto and Charon, which determines a pear-shape of the densest part of the cloud. While the production rates of escaping particles from both bodies are comparable, the lifetimes of the Charon particles inside the Hill sphere of Pluto-Charon with respect to the Sun are much longer than of the Pluto ejecta, so that the cloud is composed predominantly of Charon grains. The dust cloud is dense enough to be detected with an in situ dust detector onboard a future space mission to Pluto. The cloud's maximum optical depth of $\tau \approx 3 \times 10^{-11}$ is, however, too low to allow remote sensing observations.

Published in: *Planetary and Space Science* 50, 79 (2002 January)

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Distribution and Evolution of CH₄, N₂, and CO Ices on Pluto's Surface: 1995 to 1998

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We present new near-infrared spectra of the planet Pluto obtained at Lowell Observatory on 83 nights during 1995-1998. The dense temporal sampling of our observations enables us to measure with unprecedented detail cyclical changes in the depths of methane, carbon monoxide, and nitrogen ice absorption bands, modulated by Pluto's diurnal rotation. We show that CO, N₂, and weak CH₄ absorption band depths exhibit very different rotational patterns from Pluto's visible lightcurve, unlike the strong CH₄ absorption bands which are closely correlated with the visible lightcurve. Our observations are used to constrain the longitudinal distributions of the three ice species on Pluto's surface. The data also reveal a subtle, longer term strengthening of Pluto's strong near-infrared CH₄ bands which is used to constrain the latitudinal distribution of CH₄ ice. We simulate the observed diurnal and seasonal spectral and photometric behavior of Pluto by means of model distributions of three terrain types. We see no evidence for changes in the distributions of Pluto's surface ices during the 1995-1998 interval.

Published in: Icarus, 153, 248 (2001 October)

For reprints, contact grundy@lowell.edu

Spatial and Compositional Constraints on Non-ice Components and H₂O on Pluto's Surface

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We present four new near-infrared spectra of Pluto, measured separately from its satellite Charon during four HST/NICMOS observations in 1998, timed to sample four evenly-spaced longitudes on Pluto. Being free of contamination by telluric absorptions or by Charon light, the new data are particularly valuable for studies of Pluto's continuum absorption. Previous studies of the major volatile species indicate the existence of at least three distinct terrains on Pluto's surface: N₂-rich, CH₄-rich, and volatile-depleted. The new data provide evidence that each of these three terrains has distinct near-infrared continuum absorption features. CH₄-rich regions appear to show reddish continuum absorption through the near-infrared spectral range. N₂-rich regions have very little continuum absorption. Visually-dark, volatile-depleted regions exhibit intermediate continuum albedos with a bluish continuum slope. By analogy with Triton, we expected that careful spectral modeling would reveal strong evidence for the existence of H₂O ice on Pluto's surface, but we found only very weak evidence for its existence in the volatile-depleted regions. These data require H₂O ice to play a much less prominent role on Pluto's surface than it does on Triton's.

To appear in: Icarus

For reprints, contact grundy@lowell.edu

The Temperature Dependent Spectrum of Methane Ice I between 0.7 and 5 μm and Opportunities for Near-infrared Remote Thermometry

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New infrared absorption coefficient spectra of pure methane ice I were measured at temperatures between 30 and 90 K, over wavelengths from 0.7 to 5 μm , along with spectra of methane ice II at 20 K and liquid methane at 93 K. The spectra were derived from transmission measurements through monocrystalline samples grown in a series of closed cells having interior dimensions ranging from 100 μm to 1 cm. The thicker samples permitted measurement of extremely weak absorption bands, with absorption coefficients as small as 0.003 cm^{-1} . We report fourteen new absorption bands, which we tentatively assign to specific vibrational transitions. Two of the new bands are attributed to CH_3D . Measurements of the weaker CH_4 bands are particularly needed for interpreting spectral observations of Pluto and Triton, where a number of weak CH_4 ice absorption bands have been observed. The data presented in this paper complement studies of spectral transmission by thin films of methane ice, which are most suitable for measuring the stronger absorption bands. Temperature-dependent spectral features revealed by the new data offer the opportunity to determine CH_4 ice temperatures remotely, via near-infrared reflectance spectroscopy. This approach could prove particularly valuable for future spacecraft exploration of Pluto.

To appear in: Icarus

For preprints, contact `grundy@lowell.edu`

or on the web at <http://www.lowell.edu/~grundy/ice.html>

OTHER PAPERS OF INTEREST

How Long-Lived are the Hypothetical Trojan Populations of Saturn, Uranus, and Neptune?

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Submitted to: Icarus

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or on the web at <http://www.boulder.swri.edu/~luke/trojan.html>

CONFERENCE CONTRIBUTIONS

The 33rd Lunar and Planetary Science Conference is taking place on 2002 March 11–15 in League City, Texas, USA. Information about the meeting and the program are online at:

<http://www.lpi.usra.edu/meetings/lpsc2002/>

Below are two Kuiper belt-related papers to be presented at the LPSC, as well as information about the NRC Decadal Survey's Town Hall meeting that will be held there.

- Session 43. **NRC Decadal Survey Town Hall Meeting**
Wednesday, 2002 March 13, 12:30–1:30 (Salon B)
M.J. Belton and C. Hartman
<http://www.lpi.usra.edu/meetings/lpsc2002/pdf/sess43.pdf>
- Session 80. **Origins: Stardust to Phyllosilicates**
Friday, 2002 March 15, 8:30 (Salon A)
<http://www.lpi.usra.edu/meetings/lpsc2002/pdf/sess80.pdf>
 - *Secular Resonance Sweeping in a Self-Gravitating Planetesimal Disk, with Application to the Kuiper Belt*
J. Hahn and W. Ward
<http://www.lpi.usra.edu/meetings/lpsc2002/pdf/1930.pdf>
 - *Protoplanetary Migration and Creation of Scattered Planetesimal Disks*
B.D. Lindsay and T.W. Hyde
<http://www.lpi.usra.edu/meetings/lpsc2002/pdf/1097.pdf>

CONFERENCE INFORMATION

From Here to Pluto-Charon: A New Horizons PKB Mission Workshop

May 20–21, 2002

Southwest Research Institute, Boulder, Colorado, USA

The New Horizons Pluto-Kuiper Belt project will hold a 2-day workshop in support of mission science and broad mission participation by community members. The New Horizons project is organizing this workshop in order to better inform the community of mission plans and participation opportunities, and to solicit community input on scientific topics crucial to mission planning. The two themes of the workshop are: predictions for the time of the encounter, and groundbased and spacebased observations from the present to 2015 in support of encounter planning.

For workshop details see: <http://www.boulder.swri.edu/~layoung/PKBWorkshop02/>

For workshop questions, please email: pkbworkshop@boulder.swri.edu

Meeting Organizers:

Andy Cheng (APL): Andy.Cheng@jhuapl.edu, 240-228-5415

Leslie Young (SwRI): layoung@boulder.swri.edu, 303-546-6057

THESES

Signatures of Planets: Observations and Modeling of Structure in the Zodiacal Cloud and Kuiper Disk

E.K. Holmes¹

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There is a possible connection between structure in evolved circumstellar disks and the presence of planets, our own zodiacal cloud being a proven example. Asymmetries in such a disk could be diagnostic of planets which would be otherwise undetectable. Using COBE DIRBE observations, we link structure in the zodiacal cloud, namely the warp and offset of the cloud, to the presence of planets using secular perturbation theory. In addition, we obtain supplementary ISO observations and determine a scale factor for the data which we apply to calibrate the data to the observed COBE brightness.

A Kuiper dust disk will have a resonant structure, with two concentrations in brightness along the ecliptic longitude arising because 10–15% of the Kuiper belt objects are in the 3:2 mean motion resonance with Neptune. We run numerical integrations of particles originating from source bodies trapped in the 3:2 resonance and we determine what percentage of particles remain in the resonance for a variety of particle and source body sizes. The dynamical evolution of the particles is followed from source to sink with Poynting-Robertson light drag, solar wind drag, radiation pressure, the Lorentz force, neutral interstellar gas drag, and the effects of planetary gravitational perturbations included.

We then conduct an observational search in the 60 μm COBE data for the Kuiper disk, which is predicted to be, at most, a few percent of the brightness of the zodiacal cloud. By removing emission due to the background zodiacal cloud and the dust bands, we expect to see the trailing/leading signature of Earth's resonant ring. However, when subtracted from the data, we find that none of the empirical background zodiacal cloud models give the residuals predicted by theory. We conclude that a dynamical two-component (both inner and outer) zodiacal cloud model must be created to complete the search.

Lastly, we extend our work outside the solar system and obtain upper limits on the flux around ten Vega-type stars using the Sub-millimeter Telescope Observatory in the 870 μm and 1300 μm wave bands, which will be used to determine the most promising candidates for future observations.

Dissertation directed by S. F. Dermott

Ph.D. awarded May, 2002 from the University of Florida

Contact: elizabeth.holmes@jpl.nasa.gov

The *Distant EKO*s Newsletter is dedicated to provide researchers with easy and rapid access to current work regarding the Kuiper belt (observational and theoretical studies), directly related objects (e.g., Pluto, Centaurs), and other areas of study when explicitly applied to the Kuiper belt.

We accept submissions for the following sections:

- ★ Abstracts of accepted papers
- ★ Titles of submitted (but not yet accepted) papers and conference articles
- ★ Thesis abstracts
- ★ Short articles, announcements, or editorials
- ★ Status reports of on-going programs
- ★ Requests for collaboration or observing coordination
- ★ Table of contents/outlines of books
- ★ Announcements for conferences
- ★ Job advertisements
- ★ General news items deemed of interest to the Kuiper belt community

A L^AT_EX template for submissions is appended to each issue of the newsletter, and is sent out regularly to the e-mail distribution list. Please use that template, and send your submission to:

`ekonews@boulder.swri.edu`

The *Distant EKO*s Newsletter is available on the World Wide Web at:

`http://www.boulder.swri.edu/ekonews`

Recent and back issues of the newsletter are archived there in various formats. The web pages also contain other related information and links.

*Distant EKO*s is not a refereed publication, but is a tool for furthering communication among people interested in Kuiper belt research. Publication or listing of an article in the newsletter or the web page does not constitute an endorsement of the article's results or imply validity of its contents. When referencing an article, please reference the original source; *Distant EKO*s is not a substitute for peer-reviewed journals.

Moving ... ??

If you move or your e-mail address changes, please send the editor your new address. If the newsletter bounces back from an address for three consecutive issues, the address will be deleted from the mailing list. All address changes, submissions, and other correspondence should be sent to:

`ekonews@boulder.swri.edu`